CHINA SCHOLARSHIP COUNCIL

Appel à projets
Campagne 2022
https://www.sorbonne-universite.fr

Title of the research project: Applicability of bacterial membrane lipids as environmental proxies in lacustrine settings

Thesis supervisor (HDR) :

Name: Arnaud

Surname: Huguet

Title: Dr.

email: arnaud.huguet@sorbonne-universite.fr

Professional address:
UMR METIS
Sorbonne Université
Campus Pierre et Marie Curie
Tour 56/66 4e étage
4 Place Jussieu
75252 Paris cedex 05

Research Unit

Name : METIS (Milieux Environnementaux, Transferts et Interactions dans les Hydrosystèmes et les Sols)

Code *(ex. UMR xxxx)* : UMR 7619

Doctorate School

Thesis supervisor's doctorate school (candidate's futur doctoral school) : ED 398 (Géosciences, Ressources Naturelles et Environnement)

PhD student currently supervised by the thesis supervisor (number, year of the first inscription) : 3

(Charly Favreau, 2019, 20%, ED227; Louis Rouyer, 2020, 50% supervision, ED398; Zhe-Xuan Zhang, 2020, 50% supervision, ED 398)

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Joint supervisor :

Name : Pierre Surname: Sabatier

Title : Dr.

email : pierre.sabatier@univ-smb.fr

Professional adress :
Université Savoie Mont Blanc
Laboratoire EDYTEM
Bâtiment « Pôle Montagne »
5, bd de la mer Caspienne
F-73376 Le Bourget du Lac cedex

Research Unit

Name : EDYTEM

Code *(ex. UMR xxxx)* :UMR 5204

École doctorale

Joint supervisor's doctorate school : Or, if non SU : ED 489 SISEO

PhD student currently supervised by the joint supervisor (number, year of the first inscription) : 3
Maude Biguenet (2018, 50%) Renaldo Gastineau (2018, 50%), François Lemot (2021, 33%).

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Description of the research project (*ENGLISH*):

1) Study context

Investigating past climatic variations is essential to understand and predict future environmental changes. Paleoclimate studies are chiefly carried out for marine environments because environmental proxies were mainly developed and used for oceanic settings. However, it is essential to develop new proxies also applicable to continental (both terrestrial and aquatic) environments to assess climatic variability over the continents and improve our understanding of both past environment and global climate. Membrane lipids produced by some microorganisms can be used to this aim, as the latter are able to adjust their membrane composition in response to the prevailing environmental conditions. Thus, the structure of glycerol dialkyl glycerol tetraethers (GDGTs) – membrane lipids biosynthesised by archaea and some bacteria – is known to be related to environmental parameters[1].

Archaeal membranes are mainly constituted of isoprenoid alkyl chains ether-linked to glycerol. In aquatic settings, the relative abundance of the archaeal GDGTs was correlated with water surface temperature, leading to the development of the TEX_{86} temperature proxy[2]. More recently, GDGTs with branched alkyl chains were discovered in peat. Branched GDGTs (brGDGTs) were suggested to be produced by bacteria and are ubiquitous in aquatic and terrestrial environments. Their analysis in soils[3], peats[4] and lake sediments [5] distributed worldwide showed that their structure varies mainly with air temperature and pH, making them increasingly used as paleoproxies. BrGDGTs are the only microbial organic proxies which can be used for temperature reconstructions in both aquatic and terrestrial settings. Nevertheless, paleoenvironmental data derived from brGDGTs have to be interpreted with care, as these compounds may have allochthonous and autochthonous sources in aquatic settings and their source microorganisms are unknown. The development of new environmental proxies, independent and complementary to brGDGTs, is crucial to improve the reliability/accuracy of continental reconstructions.

3-Hydroxy fatty acids (3-OH FAs), membrane lipids predominantly produced by Gram-negative bacteria (GNB), could be used as such a proxy. They occur in both aquatic and terrestrial environments. Significant local correlations were initially obtained between the relative abundance of these compounds and temperature/pH in 26 soils collected along Mt. Shennongjia (China) [6]. We very recently extended this dataset and similarly observed significant relationships at the global level from ca. 170 soil samples collected all over the world[7, 8, 9]. A similar conclusion was very recently obtained by Wang et al. 26 from a complementary soil dataset (with ca. 190 soil samples)[10]. The recent application of 3-OH FA based-proxies to a Holocene Chinese stalagmite reinforces the potential of these compounds as terrestrial paleoenvironmental proxies [11].

These promising results were mainly obtained from soils[6, 7, 8, 9], with a single very recent study in marine settings[12] and another one in lakes[13]. The influence of environmental parameters on 3-OH FA distribution in lakes and the applicability of 3-OH FAs as temperature/pH proxies in such settings deserve further investigations, based on the high sensitivity of lacustrine archives as recorders of past environmental conditions[14].

It is now essential to obtain accurate information on the adaptation of 3-OH FA source microorganisms to temperature/pH changes in lakes to potentially developing robust and universal (paleo)environmental proxies applicable to both aquatic and terrestrial settings.

2) Details of the project

The main objectives of this work will be to investigate the applicability of 3-OH FAs as new temperature and pH proxies in lakes and to concomitantly compare these new proxies to the existing ones based on GDGTs. To this aim, the source(s) of microbial lipids in lakes will first be assessed. We then envision to develop calibrations between temperature/pH and distribution of microbial lipids in sediments from lacustrine sediments collected worldwide. Last, these calibrations will be applied to long-term paleoenvironmental reconstructions from alpine lacustrine cores.

A. Origin of microbial lipids in French Alpine lakes

The first part of this project will aim **to assess the origin of microbial membrane lipids (3-OH FAs and GDGTs) in two well-documented lakes** from the French Alps representing contrasted environmental conditions: Lake la Thuile[15] (874 m altitude; 8 m depth), with predominant terrigenous inputs and Lake Robert[16] (1998 m altitude; 12 m depth), with predominant autochthonous production. Sediment traps will be installed at 3 regular depths in each lake. The sampling strategy will involve the seasonal collection (3 times a year over 2 years, when lakes are not frozen) of (i) suspended particulate matter (SPM) from the different sediment traps and (ii) sediment at the bottom of the water column. Physicochemical water profiles will be systematically determined. After lipid extraction from sediment, 3-OH FAs and GDGTs will be analyzed using gas chromatography coupled to mass spectrometry and high-performance liquid chromatography coupled to mass spectrometry[7], respectively. These analyses will provide key information on the location (upper/bottom part of the water column and/or sediment) and period of preferential lipid production in the two lakes. Soils will also be collected in the lake watersheds. The comparison of 3-OH FA and GDGT distribution and concentration in soils, suspended matter and sediment will allow constraining the main source(s) (allochthonous/autochthonous) of these specific lipids in the two investigated lakes.

B. Abundance and distribution of microbial lipids in worldwide lacustrine sediments

The objective of the second part of the project will be to assess **if the conclusions drawn up from Lake Robert and La Thuile sediments can be generalized.** 3-OH FAs will be analyzed in sediments from 22 French Alpine lakes located along well-documented and instrumented climato-toposequences. Altitude is the main factor influencing air temperature. We will assess if the cooling of the air with altitude has an effect on the structure of the 3-OH FAs in lake sediments at the regional level and if a local temperature calibration can be developed. 3-OH FAs will also be analyzed in ca. 30 sediment cores from lakes distributed worldwide (available from the EDYTEM core repository, https://cybercarotheque.fr/). The final goal will be to develop a global correlation between mean annual air temperature and 3-OH FA distribution in lake sediments available for subsequent paleoclimate reconstructions. The influence of pH on 3-OH FA distribution will also be investigated statistically. In parallel, GDGTs will be analyzed in all samples to assess their complementarity with 3-OH FAs as temperature/pH proxies in lakes.

C. Applicability of microbial membrane lipids as paleoproxies in lacustrine archives

The aim of this last part of the project will be to examine the **applicability of microbial membrane lipids as paleoproxies.** Sediment cores will be collected in the deepest parts of lakes La Thuile and Robert, also investigated for the origin of the microbial lipids. These sites were chosen as they were the object of detailed geochemical and paleoenvironmental investigations [15, 16]. The lacustrine cores from Lakes la Thuile and Robert will provide a continuous sediment record of the last 14,000 and 12,000 cal BP, respectively, appropriate for paleoreconstruction. 3-OH FAs will be analyzed in sediments from the 2 cores. The calibrations previously established between 3-OH FA distribution and temperature/pH will then be applied to these cores to finely reconstruct environmental changes in this Northern alpine area during the Last Glacial / Holocene periods. GDGTs will also be analyzed in these cores. The lipid data from the 2 archives will be interpreted using information already available on the cores and will be compared. This will allow evaluating the applicability of 3-OH FAs as paleoproxies (temperature and pH) in lakes, independently of and concomitantly with GDGT proxies.

3) References

[1] Schouten et al., 2013. Org. Geochem. 54, 19. [2] Schouten et al., 2002. Earth Planet. Sci. Lett. 204, 265. [3] Weijers et al., 2007. Geochim. Cosmochim. Acta 71, 703. **[4] Naafs et al., 2017. Geochim. Cosmochim. Acta 208, 285.** [5] Pearson et al., 2011. Geochim. Cosmochim. Acta 75, 6225. [6] Wang et al., 2016. Org. Geochem. 94, 21**. [7] Huguet et al., 2019. Org. Geochem. 129, 1. [8] Véquaud et al., 2021. Org. Geochem. 153, 104194 [9] Véquaud et al., 2021. Biogeosciences 18, 3937.** [10] Wang et al., 2021. Geochim. Cosmochim. Acta 302, 101. [11] Wang et al., 2018. Quat. Sci. Rev. 192, 97. [12] Yang et al., 2020. Org. Geochem. 141, 103975. [13] Yang et al., 2021. Org. Geochem. 160, 104277. **[14] Arnaud et al., 2016. Quat. Sci. Rev. 152, 1**. **[15] Bajard et al., 2016. The Holocene 26. [16] Elbaz-Poulichet et al., 2020. Quat. Sci. Rev. 228, 106076.**

4) Supervision

The PhD student to be hired will benefit from the complementary expertise of the two co-PIs of the project, in organic geochemistry (A. Huguet) and paleoenvironment from lake sediment (P. Sabatier). The laboratories of the two PIs (METIS and EDYTEM) have all the analytical equipment and material available to make the project successful.

5) Profile of the Applicant (skills/diploma…)

The candidate will have a MSc degree in geosciences, analytical chemistry or environmental chemistry. Skills in organic geochemistry would be a plus. The candidate should be motivated by laboratory experiments and field campaigns. He/she should have good skills in English.

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CALENDRIER DE LA CAMPAGNE

26 juillet
Lancement de la campagne
Diffusion de l'appel à projets par les écoles doctorales auprès de leurs encadrantes et encadrants.

Jusqu'au 17 septembre
Les chercheurs/enseignants-chercheurs et chercheuses/enseignantes-chercheuses de Sorbonne Université soumettent des propositions de projets de recherche doctoraux à leur directeur et directrice d'école doctorale (en utilisant le formulaire joint) et à l'adresse suivante : **https://inscriptions.sorbonne-universite.fr/lime25/index.php/344242?lang=fr**

Jusqu'au 24 septembre
Les écoles doctorales valident le cas échéant les projets et notifie le collège doctoral de leur décision à l'adresse suivante : **csc-su@listes.upmc.fr**

1er octobre
Mise en ligne des projets validés sur le site web de Sorbonne Université et ouverture des candidatures
https://www.sorbonne-universite.fr
Les candidats chinois prennent contact avec les porteurs et porteuses de projets et leur envoient un dossier de candidature.
Les candidates et les candidats déposent leur dossier à l'adresse suivante :
https://inscriptions.sorbonne-universite.fr/lime25/index.php/383154?newtest=Y&lang=fr

31 janvier
Fermeture des candidatures
Les porteurs et porteuses de projet ont transmis la candidature retenue après audition des candidates et candidats à leur école doctorale

Jusqu'au 21 février
Après examen, les écoles doctorales envoient les lettres de pré-admission signées et tamponnées des candidats et candidates retenues au collège doctoral

28 février
Le collège doctoral envoie les lettres de pré-admission aux candidates et candidats

Jusqu'au 31 mars
Les candidates et candidats retenus par Sorbonne Université candidate sur le site internet du CSC

31 mai
Diffusion des résultats par le CSC auprès de SU
Envoi résultats aux candidates et candidats ainsi qu'aux porteurs et porteuses de projet